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INFLATION AND TAXATION WITH OPTIMIZING GOVERNMENTS

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ABSTRACT

This paper examines the empirical validity of the prediction that if governments minimize the deadweight loss from raising revenue through inflation and tax finance, there should be a positive contemporaneous association between inflation and the level of tax burdens. We examine the empirical validity of this prediction using data from Britain, France, Germany, Japan, and the United States. Inflation and tax rates are as likely to be negatively as positively correlated, so the results cast doubt on the empirical relevance of simple models in which governments with time-invariant tastes choose monetary policy to equate the marginal deadweight burdens of inflation and taxes.

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A government can satisfy its budget constraint either by printing money or by levying taxes. Each method of finance has efficiency costs. Higher inflation rates may adversely affect the economy's transaction mechanism and lead to inefficiencies in contracting. Higher taxes may distort labor supply, saving, and investment decisions. Numerous authors have examined the optimal inflation rate in the presence of tax finance, describing the behavior of governments concerned only with minimizing the deadweight burden of raising a given revenue.[1] Whether these prescriptions are consistent with actual government behavior is an unresolved and relatively unstudied issue. Mankiw (1987) reports a striking positive correlation between tax burdens and inflation rates in the postwar United States, a finding consistent with the predictions of these optimizing government models.

This paper extends previous work on the interaction between taxes and inflation. We present new empirical evidence on the correlation between inflation and tax rates in a sample of OECD countries, and conclude that optimizing models with time-invariant tastes cannot explain the observed correlations in most countries.[2] This means that other considerations must be important determinants of inflation rates. One possibility is that governments choose inflation and tax rates based on stabilization objectives. Alternatively, the government's dislike for inflation may vary over time for political or other reasons. We discuss these issues in the conclusion.

Models with and without commitment imply a positive relationship between the inflation rate and tax rates. In both cases, the marginal social cost of raising additional revenue with the inflation tax is an increasing function of the inflation rate. The marginal deadweight burden of tax finance also rises with the tax rate. An optimizing government which equates the marginal social costs of obtaining revenue from inflation and taxation will therefore raise both the

inflation rate and tax rates in response to higher revenue demands.

Readers who pay serious attention to the actual pronouncements of policy makers may believe that revenue considerations have no place in a positive theory of monetary policy. Central bankers rarely, if ever, mention the seigniorage that results from alternative monetary policies. While we view this as evidence against the class of optimizing models studied below, it might nevertheless be possible to reconcile the speeches of policy-makers with the optimizing government models. When government spending is high, governments tend to raise taxes and also to increase debt finance. Central bankers who react by purchasing government bonds with newly minted money, thereby raising seigniorage revenues, may rationalize this behavior with fear of high interest rates generated by large government debt stocks.[3] Their behavior may however be consistent with the predictions of positive models of government based on deadweight burden minimization.

Our analysis of inflation and taxation is divided into three sections. The first summarizes the links between inflation and tax policy, first when the government is able to commit, and then when it is not. Section two studies the empirical relationship between taxes and inflation in the United States, United Kingdom, Japan, West Germany and France. We show that a positive association between inflation and the level of tax burdens obtains only in the U.S. and Japanese data. The conclusion discusses why simple positive models of government behavior such as those analyzed here may be incapable of explaining monetary and fiscal policy.

1. Inflation and Taxation

This section models an optimizing government's choice of inflation and tax

rates when these policies are chosen only with regard to their revenue effects. We first consider the case where commitment is possible, then examine how the absence of commitment affects the results.

The government's objective is to minimize the expected total cost of raising revenue, given by

$$W(t) = E_t \sum_{j=0}^{\infty} \rho^j \, k[h(\theta_{t+j}) - v(\frac{P_{t+j-1}}{P_{t+j}})] \tag{1}$$

where ρ is a discount factor, θ_t equals the ratio of taxes to income (a <u>tax rate</u>) in period t, and P_t is the price level. We assume that k( ) is a monotone increasing function while h( ), the tax distortion, is increasing and convex.

The increasing and concave function v( ) gives the benefits from deflation so that the costs of inflation are -v( ). This function is not just intended to capture the distortionary effects of inflation on the demand for money, as in Drazen (1979), Phelps (1973), Kimbrough (1986) and Lucas (1986). Instead, it reflects the many possible consequences of inflation enumerated by Fischer and Modigliani (1978).[4] In particular, the government might be concerned with the distributional consequences of inflation as well as with the difficulties inflation introduces in a world with pervasive nominal contracts.

The government's budget constraint is described by the evolution of real government debt, b_t:

$$b_t = [b_{t-1}(1+i_{t-1}) + m_{t-1}] \frac{P_{t-1}}{P_t} + g_t - \theta_t y_t - m_t \tag{2}$$

where m_t, g_t, and y_t denote real money balances, real government spending, and real income respectively. The nominal interest rate is i_t. We treat government spending as exogenous, but allow real income to depend on the tax rate. Real

money balances and the nominal interest rate at t depend on anticipated inflation between t and t+1.[5]

1.1 The Commitment Case

Suppose the government chooses a tax schedule which specifies payments as a function only of past actions. Absent reputational effects, such a government will regard all taxes as nondistortionary. While there are distortions from <u>anticipation</u> of these taxes, they do not influence the government's ex post actions. A rather different situation arises when the government chooses taxes which specify payments as functions of current or future decisions. Such a government's choice of tax instruments may be guided by considerations of excess burden. At least in the United States, we routinely take government commitment regarding tax rates for granted. Income tax schedules are often legislated several years in advance. This commitment is in part just the result of time lags in the legislative process.

Monetary policy differs from fiscal policy in several important ways. First, the Federal Reserve can react quickly to changed circumstances: time lags are shorter. Second, the Fed announces its intentions about future policy only in very broad terms. There is no counterpart to the publication of future tax tables. Verifying breaches of commitment by the central bank is therefore much more difficult than identifying similar breaches by the tax authority. These considerations do not imply that commitment by the monetary authorities is impossible. Reputational forces might be strong enough to ensure that the money supply always remains on the agreed upon path. Whether central banks can commit to future actions is therefore an empirical matter.

Optimal policies with commitment can be modelled by allowing the government, which maximizes (1) subject to (2) at time t, to pick a contingency

plan for tax rates and, by choosing future money supplies, for prices at t+1. This plan, which allows taxes and inflation to depend on the realizations of all t+1 variables including g_{t+1} and y_{t+1}, is chosen before households choose their money holdings. Thus real money demand and interest rates are determined after the government chooses the next period's taxes and inflation. The government choosing taxes and inflation for period t+1 takes as given the end-of-period stock of government liabilities, $b_t + m_t$. The stock of liabilities is the only state variable for the government's problem, the sole channel through which policy choices in period t affect future values of money demand, prices, and output. The division of these liabilities between money and bonds, however, depends on the government's decisions in period t.

Holding constant the end-of-period stock of liabilities $b_t + m_t$, altering inflation between periods t and t+1 and taxes in period t+1 only affects interest rates and real money demand in period t and output in period t+1.[6] These shifts leave the path of government revenue unchanged, so at the optimum they cannot affect the government's welfare. Formally, equation (2) implies that the derivative change in the tax rate θ_{t+1} that raises enough revenue to offset a change in (P_t/P_{t+1}) holding constant the level of government liabilities at the end of period t+1 is:

$$(3) \quad y_{t+1}(1+\epsilon_\theta)d\theta_{t+1} = [-m_t + (R-P_t/P_{t+1}) \frac{dm_t}{d(P_t/P_{t+1})}] \, d(\frac{P_t}{P_{t+1}}) = -m_t(1+m_i)d(\frac{P_t}{P_{t+1}})$$

where we have assumed that real returns, $R = (1+i_t)P_t/P_{t+1}$, are constant. In our notation, ϵ_θ is the elasticity of income with respect to taxes and m_i is the elasticity of money demand with respect to the nominal interest rate. A government minimizing social losses in (1) subject to this revenue constraint

will choose tax rates and inflation rates satisfying the first order condition:

$$(4) \qquad \frac{P_t}{P_{t+1}} = \phi\left(\frac{h'(\theta_{t+1})m_t(1+m_i)}{y_{t+1}(1+\epsilon_\theta)}\right)$$

where $\phi = (-v')^{-1}$, $\phi' < 0$. This expression equates the excess burden per unit revenue for each revenue source.

Equation (4) implies that positive shocks to government spending that raise taxes and their associated excess burden should be accompanied by increases in inflation that raise the marginal excess burden from seigniorage. It also states that inflation between t and t+1 should be an increasing function of m_t/y_{t+1}. When this ratio is large, the revenue from a given inflation rate is high since, with commitment, revenue from inflation is obtained at t+1 as people replenish the money that has been depleted by inflation. When more money is carried over, these replenishments are larger and the relative cost of inflation is lower.

1.2 The No-Commitment Case

When commitment about inflation is impossible, the government in period t can only choose the tax rate and the price level at t. The government recognizes that it can cause unexpected inflation at t. Of course, if there were no exogenous uncertainty the government's problem at t would be known at t-1 so there would be no unexpected inflation in equilibrium. The equilibrium inflation rate is just that rate at which the government will not choose to induce any unexpected inflation.[7] Inflation will only be finite without commitment if it is nonethless costly so that the function v( ) does not become degenerate.

Some might argue that the costs of inflation are much lower for a government that cannot precommit. One of the costs of expected inflation, the increase in transaction costs due to economizing on money holdings at t-1, is immaterial for

such governments since the government that picks the price level at t cannot alter the choice of money holdings at t-1. Many other costs nevertheless remain even when inflation is unanticipated. For example, the government may be averse to redistributing wealth between debtors and creditors. Reestablishing the original distribution of wealth may require the use of distortionary taxes and subsidies. Alternatively, even unanticipated inflation may distort subsequent behavior by households and firms in ways the government finds undesirable. For example, workers may press for premature renegotiation of their contracts, firms may incur additional costs of changing prices and individuals may be forced to engage in additional financial transactions to restore their liquidity. Indeed, insofar the costs of inflation are due to its deleterious effects on nominal contracts, unexpected inflation may be more costly than anticipated inflation because it has not been reflected in contracts.

In the absence of commitment, the only state variable when taxes and the price level at t are chosen is the total beginning of period level of liabilities, $\ell_t = b_{t-1}(1+i_{t-1}) + m_{t-1}$. The government at t then chooses both the tax rate and nominal money balances at t. These choices determine interest rates and the price level.

At the policy optimum without commitment, the government must be indifferent to small perturbations in the policy mix which leave b_t, next period's <u>beginning</u> of period stock of government liabilities, unchanged. Feasible perturbations thus satisfy:

$$(5) \qquad y_t(1+\epsilon_\theta)d\theta_t = -\ell_t\, d(P_{t-1}/P_t).$$

This expression differs from the tradeoff in the commitment case because it excludes the response of money demand and nominal interest rates to expected

inflation. Maximizing (1) subject to (5) gives a first order condition for the no commitment case:

$$(6) \qquad \frac{P_{t-1}}{P_t} = \phi\left(\frac{h'(\theta_t)[m_{t-1} + b_{t-1}(1+i_{t-1})]}{y_t(1+\epsilon_\theta)}\right).$$

Inflation is a positive function of both taxes and total government liabilities as a share of GNP. As in the commitment case, when high deadweight burdens are being imposed with the tax instrument, higher inflation taxes will also be appropriate. The positive effect of outstanding liabilities obtains because governments with large nominal obligations will find inflation more attractive than those with less heavy debt burdens, since inflation erodes the value of these obligations.[8]

The inflationary erosion of government liabilities is totally anticipated, at least in models without stochastic disturbances. It is nevertheless possible for governments to accumulate stocks of such obligations, provided they are willing to pay sufficiently high nominal yields. It is even possible for inflation to raise no revenue: the revenue raised _ex post_ from reducing the value of bonds and money may be more than offset _ex ante_ by increases in nominal interest rates and reductions in the demand for real money balances.

2. The Empirical Relationship between Inflation and Taxes

This section evaluates the model of the previous section by examining the relationship between taxes and inflation in several nations and over several time periods.[9] We first consider the empirical counterpart of equation (4), which is valid with commitment.[10] Mankiw (1987) estimates an equation similar to this on post-war U.S. data. We also estimate the empirical counterpart of (6), the first order condition that holds without commitment.

To estimate the first order condition implied by government optimization, we must specify functional forms for h( ) and v( ), the deadweight losses due to taxation and inflation respectively. We assume constant elasticity functions so that our objective function is a generalization of the CES welfare function: $h(\theta_t) = \kappa_1 \theta_t^{\alpha+1}$ and $v(P_{t-1}/P_t) = \kappa_2 (P_{t-1}/P_t)^{1-\beta}$, for κ_1, κ_2, α and β positive constants. This implies that (4) can be written as

$$(7) \qquad \ln(P_t/P_{t-1}) = \gamma_0 + \gamma_1 \ln(\theta_t) + \gamma_2 \ln(m_{t-1}/y_t)$$

where $\gamma_1 = \alpha/\beta$ and $\gamma_2 = 1/\beta$. This specification relaxes Mankiw's (1987) assumption that the ratio of m_{t-1} to y_t is constant.

If the functions h( ) and v( ) were literally time invariant and correctly specified, equation (7) would hold without error. This literal version of our model is easy to reject. We are not, however, interested in testing the proposition that the theory can explain the exact relationship between taxes and inflation, but in exploring whether the theory can explain a substantial fraction of the movements in these series. We therefore test the prediction that higher taxes tend to be associated with higher inflation by simply adding an error term, ϵ_t, to (7) and estimating the resulting equation for several countries.

Our estimation employs annual data for five countries: the United States, Britain, France, Germany, and Japan. Our analysis is confined to taxes levied by the central government, since this is the level of government choosing monetary policy. Price indices, measured using consumer prices in each country, are annual average values. The stocks of money and debt are measured as mid-year values or yearly averages. Since both inflation and the tax rate are highly persistent, ordinary least squares estimation of (7) would recover the trends in the two series. We therefore add a time trend to (7) and estimate the resulting

equation allowing for residual autocorrelation, or we difference (7) and estimate the resulting specification by ordinary least squares.[11]

We begin by analyzing the time series evidence for the United States, using two measures of the tax rate θ_t. The first is the ratio of federal government tax receipts to GNP, each measured as flows during the calendar year. If the government chooses its mix of tax instruments optimally, then the ratio of taxes to GNP is a summary statistic for the degree of tax distortion. This is a crude tax rate, and it is available for a long time period. The second measure of the tax burden is the weighted average marginal tax rate on labor income computed by Barro and Sahasakul (1986). Their tax measure, including both federal income and Social Security taxes, is available for the 1916-1985 period. Data limitations restricted our sample period to begin in 1890, even when we use T/GNP for our tax measure.[12]

The results of estimating equation (7) for a variety of different sample periods are shown Table 1. The tax rate is positively correlated with the inflation rate for all of the sample periods, but the strength of this correlation is strongest for the post-World War II period. For the entire 1891-1986 period, a ten percentage point increase in the share of taxes in GNP predicts a one half of one percentage point increase in the inflation rate. The tax rate and trend, however, explain less than six percent of the variation in inflation rates. The estimates in the AR(1) with trend and the differenced equations are similar, with slightly larger effects of the tax rate on inflation in the latter equations. For the period since 1919 but excluding World War II, the coefficient estimates are close to those for the full sample, although now the null hypothesis of no tax effect on inflation cannot be rejected at standard levels.

This conclusion is reversed when the sample is restricted to the post-war

period. A ten percent of GNP increase in taxes now raises the inflation rate by approximately 3.4 percent, and the impact coefficient is estimated much more precisely than for the longer sample periods. When the Barro-Sahasakul marginal tax rate series is used in place of the tax-to-GNP ratio, the estimated inflation effect of a tax increase is smaller. A ten percentage point rise in the marginal tax rate raises the inflation rate by just under two percentage points.

The coefficient on $\log(m_{t-1}/y_t)$ in the full sample equations in Table 1 is negative, although the null hypothesis that it is zero cannot be rejected at standard confidence levels. Since the coefficient on this variable is $1/\beta$, the negative estimate is inconsistent with the theory underlying equation (7). The negative parameter estimates are apparently due to the pre-war sample since the estimates for the post-World War II period suggest a positive effect of the money-to-income ratio on the inflation rate. The same coefficient pattern, negative in longer samples and positive for the postwar period, emerges in both the AR(1) and the differenced estimates.[13]

Institutional changes during the postwar period, notably the shift from fixed to flexible exchange rates in 1973, could affect the stability of the coefficients linking taxes to inflation rates. We test this possibility by allowing the coefficients in (7) to differ before and after 1973. The hypothesis of constant coefficients is not rejected in any of the equations estimated over long sample periods, either 1891-1985 or 1919-1985.[14] For the postwar period, however, the AR(1) equations fail the test of subsample stability while the differenced equations do not. We examine the source of this failure by constraining γ_1 and γ_2 to be constant, while allowing the intercept and trend coefficients to differ before and after 1973. The null hypothesis of constancy for this subset of coefficients is not rejected; the $\chi^2(2)$ statistics are 1.96

when the tax rate variable is T/GNP, and 3.66 with the Barro-Sahasakul marginal tax rate series (the .05 critical value for a $\chi^2(2)$ random variable is 5.99).

Our findings for the United States strengthen Mankiw's (1987) conclusions based on the postwar period. To evaluate the robustness of the positive relationship between inflation and tax rates, however, we now consider data from four additional countries. For France, Germany, and Japan, we draw data from the International Monetary Fund International Financial Statistics for the postwar period to construct tax-to-GNP ratios and inflation rates.[15] More extensive data are available for Britain. For the period 1872-1985, we constructed a tax-to-GNP ratio using data from British Historical Statistics and various issues of the Annual Abstract of Statistics. The annual price index was measured using the Retail Price Index (post-1948) and the Statist price index.[16]

Tables 2 reports estimates of (7) for these four countries. The positive association between inflation and taxes that appears in U.S. data does not generalize. The French and British data show a statistically significant and negative relationship between tax levels and the inflation rate. In Germany the relation is again negative although the standard error of the estimated coefficient is too large to reject the null hypothesis of no tax effect. Only the Japanese data confirm the U.S. finding of a positive relationship between inflation and taxes. A ten percent of GNP increase in the tax burden is estimated to increase the inflation rate by 3.1 percent in the AR(1) specification, and by 4.7 percent in the differenced model. The estimated effects of the money-to-income ratio are positive in each equation in Table 2, in contrast to the often negative coefficients for the United States.[17]

We repeated our analysis of subsample stability for the equations reported in Table 2. Constancy of γ_1 and γ_2 is not rejected for the U.K., Germany, or

Japan. In France, however, there is evidence of parameter instability. In equation (7) with all coefficients free to change in 1974, the pre-1974 estimate of γ_1 is -.56 (.10), with an estimated change for the period after 1974 of .79 (.63). Most of the evidence against parameter constancy arises from the change in the coefficient on the money-to-income ratio, however. The pre-1974 estimate is .53 (.08), while the change is -.51 (.13).

The first four rows of Table 2 report country-by-country estimates of equation (4). These estimates ignore the information about inflation rates in one country that may be contained in the coincident experience of other nations. To remedy this problem, we also estimated the equations for the post-war period in all countries using the seemingly unrelated regression technique. The resulting estimates are shown in Table 3, and are quite similar to the country-by-country findings in Table 2. The last row of Table 3 reports estimates which constrain γ_1 and γ_2 to be constant across countries. The levels equation yields a small and statistically insignificant coefficient linking tax rates and inflation rates. In the differenced specification, even though three of the five countries show negative coefficients when estimated alone, the constrained estimate of γ_1 is .11 (.03). In both specifications, however, the hypothesis of constant (γ_1, γ_2) across countries is clearly rejected.[18] We therefore focus primarily on the unconstrained results, which yield a negative correlation between inflation and tax rates in three of the five countries.

Our failure to find a positive association between tax rates and inflation might be due to an incorrect specification. We have assumed that governments can either precommit or that they can tax outstanding government debt without resorting to inflation. If these assumptions are incorrect, the first-order condition linking taxes and inflation rates is equation (6) which includes the

government's outstanding interest bearing debt. Under the same parametric assumptions used to derive (7) from (4), the version of (6) that we estimate is:

$$(8)\quad \ln(P_t/P_{t-1}) = \gamma_0 + \gamma_1 \ln(\theta_t) + \gamma_2 \ln[(b_{t-1}(1+i_{t-1}) + m_{t-1})/y_t] + \epsilon_t .$$

Since the earlier results suggest that differencing and autoregressive corrections with time trends yield similar results, we present only the latter.

Table 4 reports estimates of (8) for all five countries in our sample. The inclusion of the broad government liabilities variable does not substantively alter our estimates of the association between taxes and inflation. In particular, the coefficient on the tax rate remains negative and statistically significant for Britain and France, positive and significant for Japan and the United States, and statistically insignificant for Germany. The broad liability measure is less correlated with inflation than $\ln(m_{t-1}/y_{t-1})$. The point estimates for the total liability variable are negative (i.e., incorrectly signed) for Germany and Japan, whereas the money-to-GNP ratio had the sign predicted by the foregoing theory.

The superiority of models including only the ratio of money to GNP, relative to models with total government liabilities as a share of GNP, can be demonstrated by estimating regression equations which include both variables. This is equivalent to the non-nested hypothesis test of the null hypothesis that one variable affects the inflation rate against the alternative that the other variable affects it. For the U.S., Germany, and Japan, including both variables yields a negative coefficient on the liability variable but a positive and usually statistically significant coefficient on the money variable. For France both variables have positive and statistically insignificant coefficients, while for Britain both are positive and statistically significant, but the coefficient

on money is roughly three times as large as that on the broader liability measure. Overall, the results are more supportive of a specification including the ratio of lagged money to GNP than the total level of government liabilities.[19]

3. Conclusions

The view that governments use both taxes and inflation to raise revenue while attempting to minimize total deadweight loss cannot explain our finding that higher taxes are just as often associated with lower as with higher inflation. The positive association between inflation and tax rates in U.S. time series data which has been cited as support for the optimizing government model of monetary and fiscal policy does not recur in other nations.

Several explanations may be advanced to account for our results. One is that governments are unable to adjust the structure of taxes frequently enough to enforce the first order conditions implied by optimizing models. This view is implicit in the work of Feldstein (1983) and others who view the effects of inflation on tax burdens as largely accidental and unanticipated. Even when tax rules are costly to change, however, policy makers could implement the links between taxes and inflation described above. An unindexed tax system which raises corporate tax burdens during inflationary periods because depreciation is based on historic cost, for example, generates a positive association between tax rates and inflation.

A second possibility, which we regard as more promising, is that the government's objective function which guides inflation and tax policy varies over time. The perceived costs of inflation and taxes may change with the political party in power, shifts in voter preferences, or changes in the transactions or

tax-collecting technology.[20] Models of "political business cycles," which predict variation in the policy preferences of given political actors, or models of multiparty government with intertemporal variation in the identity of political actors, could explain our findings. Alesina and Sachs (1988) provide some support for the view that different political parties in the United States have different macroeconomic preferences, and Hibbs (1986) documents intertemporal variation in the inflation-unemployment preferences of the U.S. electorate. If governments that are willing to tolerate inflation also like expansionary policies in general, then total revenues will decline in periods of high inflation, reinforcing the negative inflation-tax correlation.[21]

The view that negative inflation-tax correlations are due to unstable government tastes is mildly supported by the fact that countries with more stable governments and less diverse political parties, such as postwar Japan and the United States, exhibit positive tax-inflation correlations. Countries with more political instability, such as Britain and France, tend to exhibit negative correlations. Roubini and Sachs (1988) present intriguing evidence on other links between political structure and the nature of fiscal policy. Further work could usefully explore how political institutions or other aspects of social structure are related to the inflation-tax correlation.

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Table 1: U.S. Time Series Evidence on Inflation and Tax Rates

	Level Specification						Difference Specification			
Sample/Tax Rate	Constant	Tax Rate	M/Y	Trend	AR(1)	R^2	Constant	Tax Rate	M/Y	R^2
1891-1985/TGNP	.093	.051	-.050	-.0011	.579	.052	-.001	.062	-.072	.031
	(.088)	(.024)	(.031)	(.0008)	(.084)		(.004)	(.032)	(.059)	
1919-40,1946-1985/TGNP	.039	.039	-.022	.0002	.411	.157	-.003	.063	-.078	-.002
	(.113)	(.034)	(.034)	(.0012)	(.118)		(.006)	(.057)	(.078)	
1919-40,1946-1985/MTR	.043	.030	-.017	-.0001	.409	.163	-.003	.059	-.082	.013
	(.105)	(.023)	(.030)	(.0012)	(.118)		(.006)	(.041)	(.078)	
1946-1986/TGNP	.572	.320	.205	.007	.543	.452	.009	.334	.294	.464
	(.145)	(.074)	(.056)	(.002)	(.148)		(.004)	(.069)	(.064)	
1946-1986/MTR	.382	.177	.170	.004	.542	.334	.0007	.184	.271	.090
	(.145)	(.059)	(.062)	(.002)	(.141)		(.0041)	(.059)	(.072)	

Estimates correspond to equation (14) in the text. Standard errors are reported in parentheses. All equations are estimated by ordinary least squares.

Table 2: International Evidence on Inflation and Tax Rates

	Level Specification						Difference Specification			
Sample/Tax Rate	Constant	Tax Rate	M/Y	Trend	AR(1)	$\bar{R}^2$	Constant	Tax Rate	M/Y	$\bar{R}^2$
France/TGNP	-.332	-.681	.252	.013	.805	.647	.011	-.589	.302	.598
1948-1985	(.250)	(.132)	(.076)	(.003)	(.095)		(.008)	(.129)	(.075)	
Germany/TGNP	.175	-.041	.088	.0014	.595	.121	.0014	-.084	.076	.077
1954-1984	(.130)	(.107)	(.038)	(.0011)	(.159)		(.0022)	(.112)	(.039)	
Japan/TGNP	1.264	.313	.228	-.008	.796	.349	-.011	.472	.187	.440
1955-1984	(.337)	(.226)	(.103)	(.004)	(.121)		(.007)	(.230)	(.101)	
U.K./TGNP	.734	-.243	.778	.010	.957	.755	.011	-.236	.789	.765
1872-1984	(.235)	(.051)	(.044)	(.002)	(.026)		(.005)	(.050)	(.044)	
U.K./TGNP	-.501	-.094	.425	.015	.772	.502	.015	-.130	.468	.527
1947-1984	(.170)	(.081)	(.076)	(.003)	(.103)		(.005)	(.085)	(.076)	

Estimates correspond to equation (7) in the text. Standard errors are shown in parentheses. Equations are estimated using OLS country-by-country with no cross-equation constraints or allowance for contemporaneous residual correlation.

Table 3: International Evidence on Inflation and Tax Rates: SUR Evidence

Sample/Tax Rate	Level Specification					Difference Specification		
	Constant	Tax Rate	M/Y	Trend	AR(1)	Constant	Tax Rate	M/Y
France/TGNP 1948-1985	-.506 (.349)	-.575 (.109)	.221 (.067)	.0078 (.0018)	.899 (.072)	.0080 (.0071)	-.541 (.110)	.222 (.064)
Germany/TGNP 1954-1984	.095 (.147)	-.073 (.086)	.097 (.032)	.0014 (.0008)	.557 (.152)	.0013 (.0018)	-.100 (.084)	.087 (.028)
Japan/TGNP 1955-1984	2.106 (.360)	.544 (.162)	.181 (.074)	-.0113 (.0029)	.969 (.048)	-.0096 (.0047)	.519 (.158)	.152 (.071)
U.S./TGNP 1948-1985	.312 (.130)	.172 (.057)	.074 (.062)	.0029 (.0018)	.493 (.104)	.0066 (.0043)	.213 (.054)	.224 (.071)
U.K./TGNP 1948-1984	.025 (.104)	-.017 (.060)	.265 (.060)	.0098 (.0021)	.601 (.088)	.0130 (.0050)	-.018 (.060)	.410 (.058)
Constrained		.0029 (.0337)	.123 (.025)				.106 (.033)	.142 (.024)

Estimates correspond to equation (7) in the text. Standard errors are shown in parentheses. Equations are estimated by seemingly unrelated regressions. The likelihood values for the systems allowing free parameters for c_1 and c_2 in each equation are 489.63 in the levels system, 486.25 in differences. The likelihood values for the constrained systems, allowing free intercepts and (in the first system) time trend and autocorrelation coefficients, are 463.63 and 454.18 respectively.

Table 4: Inflation, Nominal Liabilities, and Tax Rates: International Evidence

Country/ Sample	Tax Rate Measure	Constant	Tax Rate	Government Liabilities	Trend	ρ	R^2
France 1948-85	T/GNP	-.778 (.180)	-.770 (.119)	.259 (.099)	.0185 (.0043)	.709 (.119)	.643
Germany 1954-84	T/GNP	-.0024 (.1410)	.037 (.108)	-.029 (.028)	.0012 (.0013)	.530 (.167)	.043
Japan 1957-83	T/GNP	1.178 (.346)	.841 (.222)	-.167 (.043)	-.063 (.003)	.477 (.185)	.352
U.K. 1872-1984	T/GNP	-1.335 (.317)	-.479 (.060)	.693 (.049)	.0085 (.0034)	.976 (.016)	.669
U.K. 1947-1984	T/GNP	-2.733 (0.535)	-.241 (.087)	.594 (.098)	.025 (.005)	.900 (.062)	.539
U.S. 1891-1985	T/GNP	.201 (.082)	.074 (.024)	-.055 (.019)	-.0001 (.0007)	.513 (.089)	.115
U.S. 1946-85	MTR	.311 (.186)	.184 (.062)	.063 (.043)	-.0003 (.0020)	.678 (.121)	.228
U.S. 1946-1985	T/GNP	.414 (.184)	.288 (.079)	.071 (.042)	.0022 (.0017)	.700 (.119)	.301

Estimates correspond to equation (8) in the text. Values in parentheses are standard errors. All equations are estimated by ordinary least squares.

1. Previous studies include Phelps (1973), Calvo (1978), Drazen (1979), Helpman and Sadka (1979), Kimbrough (1986), Lucas (1986), and Romer (1987).

2. Roubini and Sachs (1988) have independently tested the predictions of the optimizing government models with respect to inflation and tax rates. They study a sample of fifteen OECD countries for the period since 1960, and find virtually no support for these models outside the United States.

3. Our analysis only applies if the central government and the central bank are actually cooperating. Alesina and Tabellini (1987) present a model in which these arms of government behave noncooperatively.

4. Because we consider relatively many effects of inflation, there is no presumption, as in the more narrow models of Kimbrough (1986) or Faig (1987), that the optimal tax rate on money is given by the Friedman rule. This presumption actually disappears as soon as money services are not viewed as perfect substitutes for other arguments in the utility function (see Romer (1987)).

5. Real money balances could also depend on income and taxes without altering our substantive conclusions, although for simplicity we ignore these effects through most of our analysis.

6. Inflation in period t+1 is defined as the change in the price level between t and t+1.

7. The structure of this model resembles that of Barro and Gordon (1983), although they do not consider the revenue created by inflation.

8. If the government has access to a tax levied solely on the income from government bonds, then it is again the level of money and not the stock of nominal liabilites outstanding which affects the inflation rate. The reason is that there is now another instrument for taxing bonds, so there is no need to make inflation depend on their stock. These issues are explored in more detail in an earlier version of this paper, available from the authors on request.

9. Under our assumption that the Fisher hypothesis holds, the empirical results do not depend on whether inflation or the nominal interest rate is used as the dependent variable. Mankiw (1987) found similar results in the United States time series using both dependent variables.

10. It is also valid in a world without commitment if the government has access to taxes on bonds.

11.Some might argue that inflation and the tax-to-GNP ratio are affected by many common factors, and that a more appropriate test of the theory would focus on the variation in each due to changes in government outlays. We performed such tests, estimating (7) by instrumental variables with T/GNP treated as endogenous and using the ratio of government consumption to GNP as an instrument. For the U.S., the IV results were similar to the OLS findings, but for the other nations, γ_1 changed erratically and the standard errors substantially, making it impossible to draw any firm conclusions. The null hypothesis that $\gamma_1 = 0$ would not be rejected by the IV results for any nation except the United States.

12. The Consumer Price Index for the United States is reported in Historical Statistics of the United States, and was updated using the Economic Report of the President. The money stock is the stock of high powered money, reported in

Friedman and Schwartz (1982, Table 4.8). The interest rate is the nominal call money rate, again as reported in Friedman and Schwartz with updates by the authors. Government debt is measured as the publicly-held stock of government debt on July 1 of each year, as reported in Federal Reserve Board, Banking and Monetary Statistics.

13. Mankiw (1987) excludes the m_{t-1}/y_t variable, assuming both that the quantity equation holds, so that m_t/y_t is constant, and that observations are sufficiently close together (as they are in his continuous-time theoretical model) so that the difference between m_t and m_{t-1} can be ignored. To verify that our results are not due to our inclusion of $\log(m_{t-1}/y_t)$, we also estimated a modified version of (7) excluding this variable. The estimated coefficients on the tax rate variable decline slightly, and the standard errors increase. The overall conclusions about the links between tax rates and inflation are not affected by this change in specification.

14. The likelihood ratio test statistic for the constant-coefficient hypothesis when (7) is estimated in levels with an AR(1) correction is 4.26 for the 1891-1985 sample, and 5.92 for the 1919-40, 1946-85 sample. Both tests have four degrees of freedom (the constant and time trend coefficient are also allowed to vary). The .05 level of the $\chi^2(4)$ distribution is 9.50.

15. Data on annual averages of consumer price indexes, as well as reserve money, government debt outstanding, gross domestic product, and call money interest rates, were drawn from the IFS. In some cases these series were spliced together using values from several different IFS publications and domestic statistical sources. The tax receipts of the central government are reported in the UN

National Accounts.

16. Interest rates and the stock of high powered money are drawn from Friedman and Schwartz (1983, Table 4.9). The stock of government debt is drawn from British Historical Statistics, updated using the Annual Abstract of Statistics. Implicit in our use of data from the gold standard is the notion that seigniorage is available even when pounds are measured in terms of a commodity. Seigniorage is possible as long as the gold stock held by the government doesn't bear any relation to government minted currency.

17. As in the United States data set, excluding $\log(m_{t-1}/y_t)$ does not affect the broad character of the findings. France and Britain continue to show statistically significant negative coefficients on the tax variable. For Japan, the tax variable has an even stronger positive association with inflation when we exclude the money-to-income ratio. Finally, the coefficient on the tax share for Germany moves from negative in the equation with $\ln(m_{t-1}/y_t)$ to positive without this variable, but the coefficient is never statistically significant.

18. The likelihood ratio tests (which are distributed as $\chi^2(8)$ under the null) are 52.6 in the level specification, and 64.1 in differences.

19. If tax rates follow a martingale, then they should not be predictable using any lagged information such as past inflation rates. An earlier version of this paper explored the links between changes in tax rates and the level of inflation, yielding substantial evidence that inflation rates predict future changes in tax rates in the U.S., Britain, and France. These findings are related to Sahasakul's (1987) finding that tax rates respond strongly to transitory changes in spending, which is evidence against the martingale view.

20. Barro's (1987) analysis allows preferences to shift in this way since the government's preferred interest rate changes over time. Rogoff and Sibert's (1988) model of budget cycles could generate time-varying government preferences as the politician's desire to signal his type depends on the time until the next election.

21. The possibility that monetary policy is set based on stabilization objectives, rather than deadweight loss minimization, cannot explain our findings. Traditional Keynesian policy would call for coincident reductions in tax burdens and increases in the money stock. The observed correlation between taxes and inflation is nevertheless likely to remain positive, since stabilization policy responds to shocks. When exogenous factors cause a business slowdown, both inflation and the share of taxes in GNP are likely to decline. If the government responds with a monetary expansion accompanied by a tax cut, the ratio of taxes to GNP will be unambiguously lower than without the shock and associated stabilization. Inflation will also be lower, unless the stabilization policy more than offsets the disturbance it was designed to correct.

Appendix Table: IV Estimates of Link Between Inflation and Tax Rates

	Level Specification					Difference Specification		
Sample/Tax Rate	Constant	Tax Rate	M/Y	Trend	AR(1)	Constant	Tax Rate	M/Y
France/TGNP	.038	-.021	.011	.0016	.530	-.0110	1.320	.210
1950-1985	(.465)	(.340)	(.076)	(.0040)	(.150)	(.3601)	(3.570)	(.130)
Germany/TGNP	.238	.005	.092	.0009	.580	.0001	.081	.066
1954-1984	(.148)	(.130)	(.045)	(.0013)	(.160)	(.0040)	(.510)	(.050)
Japan/TGNP	.871	-.047	.325	-.0025	.570	-.124	7.440	-1.820
1957-1983	(.369)	(.236)	(.109)	(.0040)	(.170)	(.435)	(26.570)	(7.670)
U.K./TGNP	-.440	-.066	.473	.016	.780	.018	-.003	.505
1947-1984	(.213)	(.116)	(.107)	(.004)	(.100)	(.006)	(.200)	(.082)
U.S./TGNP	.612	.340	.190	.0060	.540	.015	1.077	.497
1946-1985	(.163)	(.083)	(.060)	(.0020)	(.150)	(.012)	(.889)	(.303)

Estimates correspond to equation (7) in the text. The tax rate is treated as endogenous and the equations are estimated by instrumental variables using the logarithm of the ratio of government consumption to GDP as the instrument for log(T/GNP). Standard errors are shown in parentheses.